# INDOOR AIR QUALITY ASSESSMENT

**Elm Street School**
**415 Elm Street**
**Walpole, Massachusetts**


Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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## Background/Introduction

At the request of Robin Chappell, Director of the Walpole Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Elm Street School, 415 Elm Street, Walpole, MA. On October 3, 2003, Cory Holmes and Shawn Sullivan, Environmental Analysts for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of this building. BEHA staff were accompanied by Kathleen Smith, Superintendent, Walpole Public Schools, Mary Grinavic, Principal, Elm Street School and Ms. Chapell. Concerns about indoor air quality related to construction/renovations prompted the request.

The Elm Street School was built in late 1960's early 1970's as a church and was under construction/renovation while occupied by students, teachers and school administration employees at the time of the assessment. The school consists of a front and back wing. The front wing houses pre-kindergarten students. The back wing houses kindergarten students. The construction/renovation project involves a new addition to connect the two wings (Picture 1) and interior renovation of the existing wings. The first floor of the back wing was undergoing renovations during the assessment; no construction/demolition was being conducted in the front wing nor on the second floor of the back wing. As part of the renovation project, the Walpole School Department hired a heating, ventilation and air conditioning (HVAC) firm to conduct a needs assessment of the existing ventilation system.

School officials provided a *Plan of Action for Air Quality Control* drafted by Bay State Contracting Co., Inc (BSC) to reduce and monitor potential air quality issues related to construction at the Elm Street School. This plan calls for a number of steps including:

- Filling voids between floors with insulation and expanding foam;

- Sealing construction barriers and doors with polyethylene plastic and tape;
- Examination of construction barriers prior to each work day as well as during the work day;
- Operation of high efficiency particulate arrestance (HEPA) filtered air machines to provide depressurization of areas under construction; and
- Keeping exterior doors to construction areas shut.

In addition to the preventative measures listed, the plan calls for improved communication and sharing of information at weekly project meetings to discuss potential air quality issues; scheduling construction work during non-occupied times, when possible; the hiring of a professional hazardous materials abatement contractor, Commonwealth Contracting Services (CCS) to perform preventative and corrective measures; and air monitoring twice a week for total volatile organic compounds (TVOCs), carbon monoxide (CO), and total airborne particulates by Guertin, Elkerton and Associates, an environmental consultant.

## Methods

BEHA staff conducted air monitoring to assess whether construction/renovation generated contaminants were migrating into occupied areas of the building. Measurements for ultrafine particles (UFPs) in combination with CO measurements were taken to identify potential pathways of combustion products. Air tests for carbon dioxide, CO, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551. Air tests for ultrafine particulates were taken with the TSI, P-Trak ™ Ultrafine Particle Counter Model 8525.

## Results

The school houses approximately 370 kindergarten and pre-kindergarten students and a staff of approximately 50. Students attend for half-day sessions (e.g., morning or afternoon). Tests were taken during normal operations at the school and appear in Table 1.

## Discussion

### Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million parts of air (ppm) in nineteen of twenty areas surveyed, indicating adequate air exchange in the majority of areas. It is important to note, however, that a number of classrooms had open windows and exterior doors or were sparsely populated, which can greatly reduce carbon dioxide levels.

Mechanical ventilation is provided by rooftop air handling units (AHUs) (Picture 2). Fresh air drawn into outside air intakes and distributed via ductwork connected to ceiling or wall-mounted air diffusers (Picture 3). Exhaust ventilation is provided by ceiling or wall-mounted exhaust grills that are ducted back to AHUs (Picture 3). It was reported by school officials that during the assessment several rooftop air handling units (AHUs) were not operating.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix I.

Temperature measurements ranged from $68^{o}$ F to $72^{o}$ F, which were close to the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of $70^{o}$ F to $78^{o}$ F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 30 to 35 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

## Renovations

It is important to note that the State Department of Education amended their regulations in 1999 to address concerns associated with school renovation projects in Massachusetts (MDOE, 1999). Renovation activities can produce a number of pollutants, including dirt, dust, particulates, and combustion products such as CO (from construction vehicles). Particles generated from construction activities can settle on horizontal surfaces in classrooms. Dusts can be irritating to the eyes, nose and respiratory tract.

The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to carbon monoxide in outdoor air. Carbon monoxide levels in outdoor air must be maintained below 9 ppm over a twenty-four hour period in order to meet this standard (US EPA, 2000). No detectable levels of carbon monoxide were measured in either outdoor or indoor air during the assessment.

The combustion of fossil fuels, welding, steel cutting, concrete/brick boring and other renovation activities can produce particulate matter that is of a small diameter (<10 μm) (UFPs), which can penetrate into the lungs and subsequently cause irritation. For this reason a device that can measure particles of a diameter of 10 μm or less was used to identify pollutant pathways from the renovation site into occupied areas.

The instrument used by BEHA staff to conduct air monitoring for UFPs counts the number of particles that are suspended in a cubic centimeter ($cm^3$) of air. This type of air monitoring is useful in that it can track and identify the source of airborne pollutants by counting the actual number of airborne particles. The source of particle production can be identified by moving the UFP counter through a building towards the highest measured concentration of airborne particles. Measured levels of particles/$cm^3$ of air increase as the UFP counter is moved closer to the source of particle production. While this equipment can ascertain whether unusual sources of ultrafine particles exist in a building or that particles are penetrating through spaces in doors or walls, it cannot be used to quantify exposure levels. The primary purpose of these tests at the school was *to identify and reduce/prevent pollutant pathways*. Air monitoring for UFPs was conducted in classrooms, hallways and other areas, which may be directly impacted due to close proximity to renovation sites. For comparison (i.e. background), measurements in areas away from renovation sites indoors as well as outdoors were taken. Increased levels of UFPs over background levels were measured in the main hallway at the base of the construction barrier (Picture 4/Table 1). Closer scrutiny revealed that this construction barrier was not sealed at the bottom.

A number of construction vehicles and several large piles of dirt/construction debris were observed around the perimeter of the building. This activity should be closely monitored to avoid the entrainment of vehicle exhaust and other construction generated pollutants inside the building via open doors or windows (Picture 5). A number of classrooms adjacent to the construction zone had open windows. The opening of windows allows for unfiltered air to enter the classroom environment carrying with it airborne dirt, dust and particulates. Dusts can be irritating to the eyes, nose and respiratory tract. Other pathways were observed for construction-generated pollutants to enter occupied areas of the building. The construction barrier in the main hallway had two holes near the top (Picture 6) and some were only partially sealed (Pictures 7 & 8). Open utility holes were seen in several of the walls separating occupied areas from construction zones (Picture 9). Finally, spaces were noted beneath the side entrance doors (Picture 10).

## Conclusions/Recommendations

A number of pathways exist for pollutants to move from areas under renovation into occupied spaces. These pathways indicate that the containment measures at the time of the assessment were not sufficient to contain pollutants related to renovation work. The following recommendations should be implemented in order to reduce the migration of renovation-generated pollutants into occupied areas and the potential impact on indoor air quality:

1. Comply with 603 CMR 38.00: School Construction – Massachusetts Department of Education. This regulation states that "[a]pplicants shall implement containment procedures for dusts, gases, fumes, and other pollutants created during renovations/construction as part of any planned construction, addition to, or renovation

of a school if the building is occupied by students, teachers or school department staff while such renovation and construction is occurring. Such containment procedures shall be consistent with the most current edition of the IAQ Guidelines for Occupied Buildings Under Construction published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA). All bids received for school construction or renovations shall include the cost of planning and execution of containment of construction/renovation pollutants consistent with the SMACNA guidelines [608 CMR 38.03(13)] General Requirements: Capital Construction" (MDOE, 1999).

2. Continue with plans to implement preventative measures listed in the aforementioned *Plan of Action for Air Quality Control.*
3. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
4. Continue to schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
5. Cover dirt/debris piles with tarps or wet down to decrease aerosolization of particulates, when possible.
6. Faculty should be aware of construction activities, which may be conducted in close proximity to their classrooms. In certain cases, classrooms adjacent to construction activities may need to have their HVAC equipment deactivated and windows closed periodically to prevent unfiltered air and vehicle exhaust from entering the building. For this reason, prior notification(s) should be made.

7. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.
8. Continue to monitor Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983). Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.
9. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the *re-entrainment* of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
10. Seal around exterior doors with weather stripping and door sweeps. Seal construction barriers on all sides with polyethylene plastic and duct tape. Seal these barriers on the construction as well as the occupied side to provide a duel barrier. Inspect these areas regularly as mentioned in the Plan to ensure integrity is maintained.
11. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.
12. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. Consider increasing the number of full-time equivalents or work

hours for existing staff (e.g. before school) to accommodate increase in dirt, dust accumulation due to construction/renovation activities. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping/mopping of all surfaces is recommended.

13. Consider changing HVAC filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

## References

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US EPA. 2000. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

**Picture 1**


**New Addition Constructed between the Front (Right) and Back (Left) Wings**

**Picture 2**

**Rooftop AHU**

**Picture 3**


**Ceiling-Mounted Supply (Left) and Exhaust Vent (Right)**

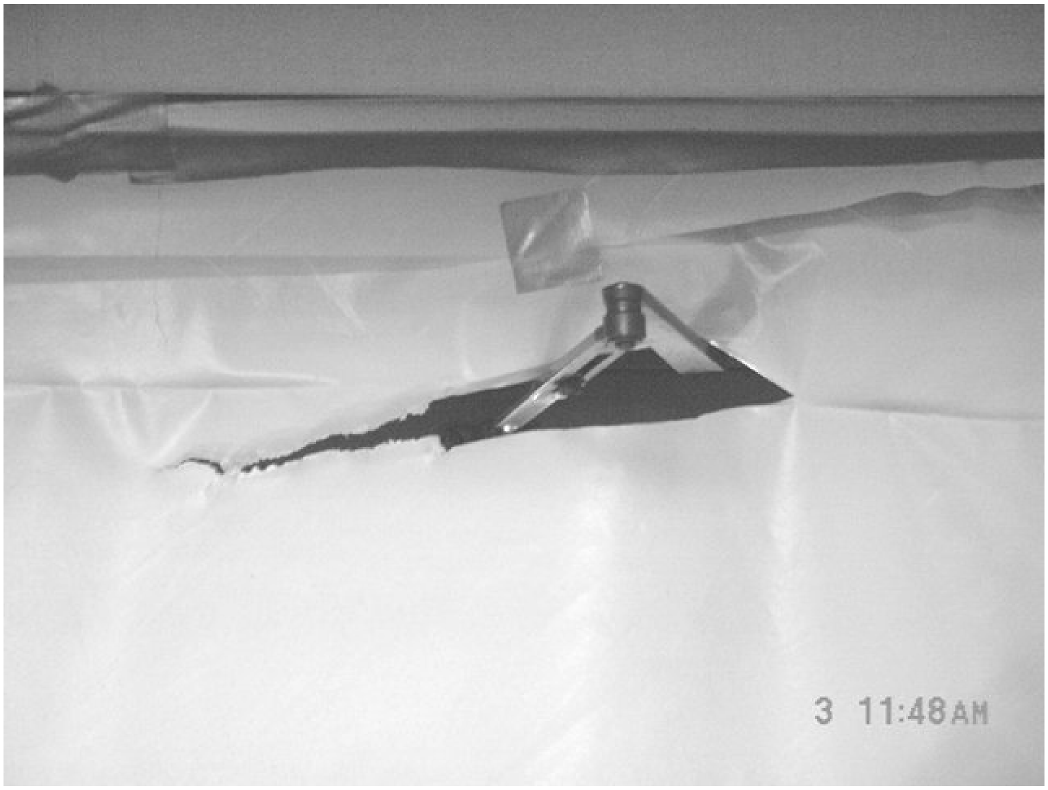
**Picture 4**

**Construction Barrier in Main Hallway, Note Plastic at Base is Not Secure**

**Picture 5**


**Construction Vehicle in Close Proximity to Building**

**Picture 6**

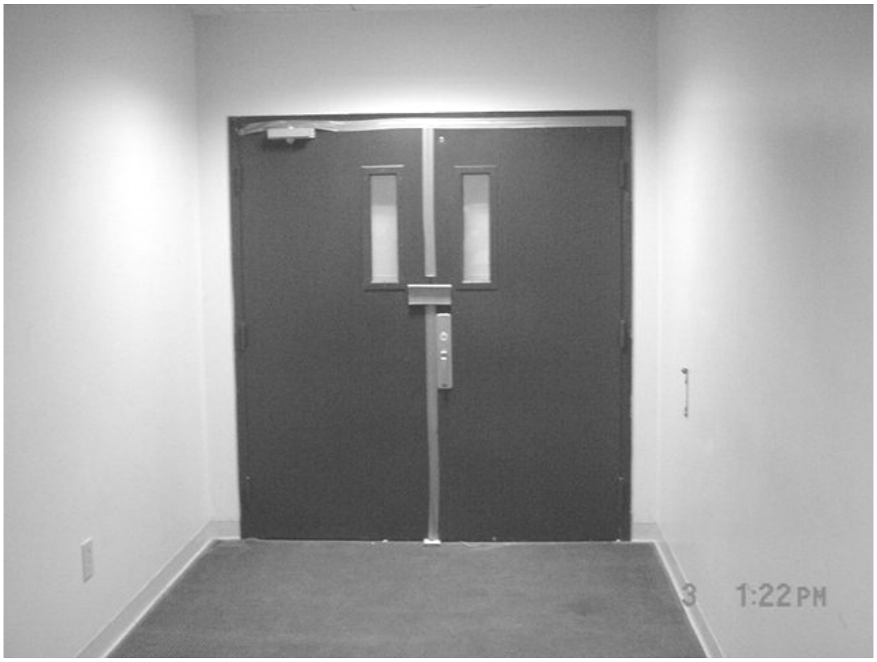



**Hole in Top of Containment Barrier for Door Hinge**

**Picture 7**


**Gypsum Wallboard Construction Barrier in Back Wing, Polyethylene Plastic Not Sealed**

**Picture 8**




**Doors in Gymnasium Hallway Partially Sealed With Duct Tape**

**Picture 9**

**Open Utility Pipes and Spaces around Pies in Wall Separating Construction/Occupied Areas**

**Picture 10**


**Spaces beneath Side Entrance Doors**

**TABLE 1**

## Indoor Air Test Results – Elm Street School, Walpole, MA – October 3, 2003

| Location | Carbon Dioxide (*ppm) | Carbon Monoxide (*ppm) | Ultrafine Particulates 1000p/cc$^3$ | Temp (°F) | Relative Humidity (%) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Supply | Exhaust | |
| Background | 355 | 0 | 8.5-9.8 | 56 | 34 | | | | | Clear sunshine, NE winds 5-10 mph |
| Auditorium | 751 | 0 | 6.5 | 71 | 32 | 50 | N | N | Y | |
| Main Hallway: Containment Wall outside Room 4 | 709 | 0 | 17.0 | 70 | 31 | | | | | Holes in plastic poly construction barrier (door hinges), poly not taped on bottom/drafts, not sealed on construction side |
| Room 1 | 670 | 0 | 7.9 | 70 | 30 | 0 | N | Y | Y | |
| Room 3 | 662 | 0 | 6.8 | 67 | 32 | 0 | N | Y | Y | |
| Media Center | 596 | 0 | 7.6 | 68 | 33 | 0 | N | Y | Y | |
| Side Entrance Doors | | 0 | 5.8 | | | | | | | Spaces under doors |
| Dorenzo | 603 | 0 | 5.6 | 69 | 32 | 1 | N | Y | Y | |
| Oliveira | 494 | 0 | 4.2 | 68 | 31 | 0 | N | Y | Y | |
| Bartucca | 507 | 0 | 5.4 | 69 | 32 | 0 | N | Y | Y | |

*** ppm = parts per million parts of air**

**Comfort Guidelines**

| | |
|---|---|
| Carbon Dioxide - | < 600 ppm = preferred |
| | 600 - 800 ppm = acceptable |
| | > 800 ppm = indicative of ventilation problems |
| Temperature - | 70 - 78 °F |
| Relative Humidity - | 40 - 60% |

TABLE 1

## Indoor Air Test Results – Elm Street School, Walpole, MA – October 3, 2003

| Location | Carbon Dioxide (*ppm) | Carbon Monoxide (*ppm) | Ultrafine Particulates 1000p/cc$^3$ | Temp (°F) | Relative Humidity (%) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Supply | Exhaust | |
| Reid | 493 | 0 | 4.0 | 69 | 31 | 0 | N | Y | Y | |
| Center Room | 475 | 0 | 5.8 | 68 | 31 | 0 | N | Y | Y | |
| Teachers Room | 928 | 0 | 4.3 | 70 | 35 | 4 | N | Y | N | |
| Special Ed | 737 | 0 | 4.6 | 71 | 35 | 1 | N | Y | Y | |
| Full Day Room | 711 | 0 | 4.9 | 71 | 35 | 0 | N | Y | Y | |
| Art Office | 711 | 0 | 4.4 | 71 | 34 | 0 | N | Y | Y | |
| Heidi's Room | 615 | 0 | 2.1 | 71 | 30 | 4 | Y | Y | Y | Window open |
| Back Building Hallway Entrance | 621 | 0 | 2.4 | 71 | 32 | 0 | | | | Sheet rock/Poly not taped, spaces around barrier, utility holes |
| Louise's Room | 621 | 0 | 2.9 | 72 | 32 | 15 | Y | Y | Y | Window open |
| Sue's Room | 644 | 0 | 1.7 | 72 | 33 | 13 | Y | Y | Y | |
| Teacher's Room Back | 563 | 0 | 2.0 | 71 | 33 | 1 | Y | Y | Y | |

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|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Supply | Exhaust | |
| Building | | | | | | | | | | |
| Conference Room | 477 | 0 | 3.5 | 70 | 31 | 0 | Y | Y | Y | |
| Extended Day Kindergarten | 480 | 0 | 3.4 | 70 | 32 | 0 | Y | Y | Y | |
| Back Building Construction Zone | | 0 | 6.3 | | | | | | | Open exterior doors/windows, utility holes |
| Gymnasium Hallway | | | | | | | | | | Recommend sealing of interior doors poly/duct tape |

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